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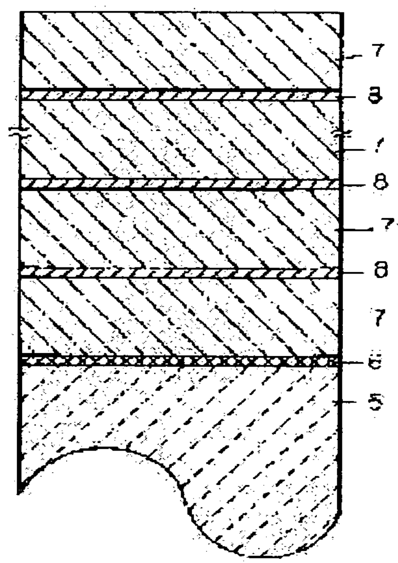
(54) SOFT MAGNETIC LAMINATE FILM AND PRODUCTION THEREOF

(57)Abstract:
PURPOSE: To isolate individual soft magnetic layers magnetically by forming an isolation layer, different from the soft magnetic layer and containing oxygen, between the soft magnetic layers.
CONSTITUTION: A substrate 5 applied with an underlying electrode 6 is immersed into a plating bath and externally applied with a current thus forming an alternate laminate layer of soft magnetic layers 7 and isolation layers 8 as an upper magnetic core pattern of a thin film magnetic head. In this regard, a pulse current subjected to a negative bias is applied and the frequency thereof is set at 100Hz or below. The composition of nickel and iron film, i.e., the allay elements composing the laminate film, is different between the soft magnetic layer 7 and the isolation layer 8 and the isolation layer 8 contains oxygen. Since the soft magnetic layers are isolated from each other but coupled magnetically in the thickness direction, unit domain can be realized at the magnetic head core part.



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CLAIMS

[Claim(s)]
[Claim 1] The soft-magnetism cascade screen which was a soft-magnetism cascade screen which consists of a soft-magnetism layer which impresses current to the electrolytic solution containing a metal ion from the exterior, and is created on the electrode, and a detached core of a non-soft magnetism, formed the detached core which contains oxygen in a layer between soft-magnetism layers, and separated each soft-magnetism layer magnetically.
[Claim 2] The soft-magnetism cascade screen according to claim 1 to which material which constitutes a soft-magnetism cascade screen is characterized by being [of nickel and cobalt] the alloy of the element more than a kind, and iron at least.
[Claim 3] The manufacture method of a soft-magnetism cascade screen using the pulse-shape current which impresses current to the electrolytic solution containing a metal ion from the exterior, and is created on the electrode and which impressed negative bias as current controlled from the outside at the time of the detached core formation which between soft-magnetism layers is the manufacture method of the soft-magnetism cascade screen separated magnetically, and separates between soft-magnetism layers.
[Claim 4] The manufacture method of a soft-magnetism cascade screen according to claim 3 that the total amount of quantity of electricity which flows to inter-electrode [in the electrolytic solution] at the time of the detached core morphosis using the pulse-shape current which impressed negative bias from the exterior was characterized by the direction of lytic reaction and bird clapper of the opposite film of the direction of plating growth reaction.
[Claim 5] The manufacture method of the soft-magnetism cascade screen according to claim 3 characterized by the frequency of the pulse-shape current used at the time of detached core formation being 100Hz or less.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the soft-magnetism cascade screen for thin film magnetic-head core material, and its manufacture method.
[0002]
[Description of the Prior Art] In recent years, in the field of magnetic recording, high recording density-ization is demanded increasingly. Hard disk drive equipment is in the flow of a mass miniaturization in it, and the technical problem for which the magnetic head is asked has improvement in the record ability to regenerate, improvement in the speed of the signal transfer rate by the reduction in an inductance, small size-ization, etc. It becomes possible to constitute the magnetic head small, in order to form the thin film magnetic head using ultra-fine processing technology, such as lithography, unlike bulk heads, such as a metal in gap (MIG) head made with machining, and to reduce an inductance. Conventionally, the 2 yuan alloy (permalloy) which consists of an about 80 at(s)% nickel and 20at(s)% iron is widely used on the magnetic-core material of the thin film magnetic head. Near [this] the composition, it has the feature that the permeability in a RF field is high, and a magnetostriction constant is about 0. Moreover, to formation of a magnetic core, the electroplating method which is a low-temperature process the cost of a membrane formation facility was low excellent also in mass-production nature is in use.

[0003]
[Problem(s) to be Solved by the Invention] Not only track recording density but the improvement in track density is required towards improvement in field recording density, and ** truck-ization is progressing also about the thin film magnetic head. For this reason, a head magnetic pole nose of cam becomes thin, and reflux magnetic-domain structure produces it in a thin film side. This is ****** about a bad influence as a noise to the record reproducing characteristics of a head. For this reason, the attempt which makes between soft-magnetism layers the composition separated magnetically is made by putting a nonmagnetic membrane between multilayering and soft-magnetism layers of the soft-magnetism film of a core portion. It was a technical problem to establish the method of forming the detached core which separates between soft-magnetism layers magnetically by controlling plating-current conditions etc. suitably from the outside from an independent bath also in an electroplating method.
[0004]
[Means for Solving the Problem] In order to attain this purpose, the detached core of this invention produced the soft-magnetism cascade screen into which each soft-magnetism layer was made to divide magnetically by forming a different detached core containing oxygen from a soft-magnetism layer between soft-magnetism layers using the pulse current to which negative bias was applied.
[0005]
[Function] In this invention, the pulse-shape current to which negative bias was applied as current controlled from the outside was used for formation of the detached core which separates between soft-magnetism layers magnetically about the soft-magnetism alloy film

which contains [CoFe / NiFe,] iron at least. Drawing 1 is an example of the current wave type when making into a square wave pulse current the current added from the outside at the time of cascade-screen formation of this invention. Drawing 2 formed the soft-magnetism cascade screen by which drawing 3 is constituted from a soft-magnetism layer and a detached core by repeating these by turns and making them into the current wave form of drawing 1 at the time of detached core formation at the time of soft-magnetism layer formation. Among drawing, (+) is the direction of a plating current and (-) is the direction of dissolution current. The positive/negative of energization quantity of electricity when forming a detached core makes plating travelling direction (+), and defines it by the difference of the area (current x hours) of the direction of (+) shown in drawing 3 , and the direction of (-). That the sum total of energization quantity of electricity at the time of detached core formation is negative (-) means that the reaction is advancing in the direction which dissolves a film. When a film is in dissolution process, it is thought according to the interface of a film and the electrolytic solution that the next reaction has occurred.
[0006] M -> Mn+ + ne- (however, M : a metal, Mn+: metal ion) -- for this reason, the soft-magnetism cascade screen from which the soft magnetic characteristics which this alloy has conventionally including oxygen deteriorated, consequently between soft-magnetism layers was separated magnetically can form a detached core continuously
[0007]
[Example] The composition of a soft-magnetism cascade screen comes to be shown in drawing 4 . The substrate 5 controlled the current which impresses from the outside production of the cascade screen which consists of a soft-magnetism layer 7 and a detached core 8 using the permalloy of 0.1-micrometer thickness formed by the vacuum deposition method or the sputtering method, and performed the usual glass substrate and the ground electrode 6 for plating.
[0008] (Example 1) It explains, referring to a drawing about one example of this invention below.
[0009] The substrate which gave the ground electrode was immersed during the plating bath shown in (Table 1), and it considered as the current wave form which shows the current added from the outside to drawing 1 , and as shown in drawing 4 , the soft-magnetism layer 7 and the detached core 8 formed the cascade screen formed by turns as a thin film magnetic-head up magnetic-core pattern.
[0010]
[Table 1]

	濃度
硫酸ニッケル6水和物	300～350g／1
塩化ニッケル6水和物	30g／1
硫酸第一鉄7水和物	5～10g／1
ほう酸	40g／1
サッカリン酸ナトリウム	1.5g／1
ラウリル硫酸ナトリウム	0.25g／1

[0011] Membranes were formed using the pulse conditions of (Table 2) with the current of pulse shape shown in drawing 1 . Front Naka described as current density (J) which is the current value per area plated [unit] (I) as a size of the pulse current to be used. Film composition of the soft-magnetism layer of the produced NiFe alloy film was nickel 80at% and iron 20at% mostly, all thickness performed 2 micrometers and detached core formation process 3 times, and the soft-magnetism layer produced the cascade screen of four layers.
[0012]

[Table 2]

軟磁性層	・矩形波パルス 周波数:10Hz ・電流密度 J_0:50mA／cm^2 ・デューティー比 (T_1／(T_1+T_2)):0.2
分離層	・矩形波パルス 周波数:10Hz ・電流密度 J_1:40mA／cm^2 J_2:80mA／cm^2 (パルス幅(J_1+J_2):120mA／cm^2 バイアス量(J_2):-80mA／cm^2) ・デューティー比 (T_3／(T_3+T_4)):0.5

[0013] A soft-magnetism layer differs in film composition of the nickel which is the alloy element from which the cascade screen which formed membranes on the pulse-current conditions of (Table 2) constitutes a cascade screen as shown in drawing 5 , and iron from a detached core, and the detached core contains oxygen in the film. As a result of magnetic-domain observation of this cascade screen, as shown in drawing 6 (a), reflux magnetic-domain structure disappears, and is single magnetic-domain structure, and membrane formation of the cascade screen magnetically separated in the direction of thickness was attained by using a pulse-current wave like this example for detached core formation. (Table 3) summarizes the magnetic-domain structure of the cascade screen which changed the pulse conditions at the time of detached core formation, and formed membranes. The direction of a plating current of the value of the sum total of front Naka and energization quantity of electricity is the direction of positive (+).

[0014]

[Table 3]

周波数 (Hz)	デューティー比 (T3/T3+T4) (−)	電流密度 パルス幅 (mA/cm^2)	バイアス (mA/cm^2)	通電電気量の合計	磁区構造
10	0.2	40	−20	(−)	パターン内単磁区
10	0.2	100	−80	(−)	パターン内単磁区
10	0.2	100	−20	零	複数磁区
10	0.2	160	−80	(−)	パターン内単磁区
10	0.5	100	−80	(−)	パターン内単磁区
10	0.5	120	−80	(−)	パターン内単磁区
10	0.5	160	−80	零	複数磁区
100	0.5	120	−80	(−)	パターン内単磁区
500	0.5	120	−80	(−)	複数磁区
10	0.75	40	−20	(+)	複数磁区
10	0.75	100	−80	(−)	パターン内単磁区

[0015] Two or more magnetic domains were observed in the pattern as the sum total of energization quantity of electricity shows to drawing 6 (b) by the cascade screen of positive (+) or zero. However, the magnetic-domain structure of the cascade screen of negative (-) is single magnetic-domain structure within the pattern. Moreover, it was checked that the frequency of the pulse current used for acquiring this single magnetic-domain structure at the time of detached core formation is effective below 100Hz.
[0016] Table 4 (Example 2) The same examination as an example 1 was performed using the shown plating bath composition. The wave of the current impressed from the outside used the wave shown in drawing 1 . Film composition of a soft-magnetism layer is iron 10at% simultaneously cobalt 90at% near a zero magnetostriction. The thickness of a cascade screen performs 2 micrometers and detached core formation process 7 times, and a soft-magnetism number of layers is eight layers. (Table 5) summarizes the magnetic-domain structure observed by the cascade screen which changed the pulse parameter of a pulse current used at the time of detached core formation, and was obtained.
[0017]
[Table 4]

	濃度
硫酸コバルト7水和物	320～400g／l
硫酸第一鉄7水和物	20～40g／l
ほう酸	40g／l
サッカリン酸ナトリウム	2.0g／l
ラウリル硫酸ナトリウム	0.25g／l

[0018]
[Table 5]

周波数 (Hz)	デューティー比 (T3/T3+T4) (-)	電流密度		通電電気量の合計	磁区構造
		パルス幅 (mA/cm^2)	バイアス (mA/cm^2)		
10	0.2	100	−80	(−)	パターン内単磁区
10	0.2	100	−20	零	複数磁区
10	0.2	160	−80	(−)	パターン内単磁区
10	0.5	120	−80	(−)	パターン内単磁区
10	0.5	160	−80	零	複数磁区
100	0.5	120	−80	(−)	パターン内単磁区
500	0.5	120	−80	(−)	複数磁区
10	0.75	40	−20	(+)	複数磁区
10	0.75	100	−80	(−)	パターン内単磁区

[0019] Also in the CoFe alloy, two or more magnetic domains were observed in the pattern by the cascade screen whose sum of energization quantity of electricity is positive (+) or zero at the time of detached core formation process. The magnetic-domain structure of the cascade screen which is negative (-) turned into single magnetic-domain structure within the pattern to it. Moreover, single magnetic-domain structure was acquired for the frequency of the pulse current used at the time of detached core formation on conditions 100Hz or less. Moreover,

when a soft-magnetism number of layers was made into eight layers, that the same effect is acquired has checked from this example.
[0020] Table 6 (Example 3) The same examination as an example 1 was performed by the CoNiFe alloy system of 3 yuan using the shown plating bath composition. Film composition of a soft-magnetism layer is iron 45at% nickel 35at% cobalt 20at% mostly. The thickness of a cascade screen makes 3 times 2 micrometers and detached core formation process, and a soft-magnetism number of layers is four layers. (Table 7) summarizes the magnetic-domain structure observed by the cascade screen which changed the pulse parameter of a pulse current used at the time of detached core formation, and was obtained.
[0021]
[Table 6]

	濃度
硫酸コバルト7水和物	75～100g／1
硫酸ニッケル6水和物	150～200g／1
硫酸第一鉄7水和物	20～40g／1
ほう酸	40g／1
サッカリン酸ナトリウム	2.0g／1
ラウリル硫酸ナトリウム	0.25g／1

[0022]
[Table 7]

周波数 (Hz)	デューティー比 (T3／T3+T4) (−)	電流密度		通電電気量の合計	磁区構造
		パルス幅 (mA／cm^2)	バイアス (mA／cm^2)		
10	0.2	100	−80	(−)	パターン内単磁区
10	0.2	100	−20	零	複数磁区
10	0.5	120	−80	(−)	パターン内単磁区
10	0.5	160	−80	零	複数磁区
100	0.5	120	−80	(−)	パターン内単磁区
300	0.5	120	−80	(−)	複数磁区
500	0.5	120	−80	(−)	複数磁区
10	0.75	40	−20	(+)	複数磁区
10	0.75	80	−60	零	複数磁区
10	0.75	100	−80	(−)	パターン内単磁区

[0023] In the cascade screen whose sum of energization quantity of electricity of pulse-shape current used also about this CoNiFe alloy system of 3 yuan at the time of formation of a detached core is positive (+) or zero, two or more magnetic domains were observed in the pattern. The magnetic-domain structure of the cascade screen which is negative (−) turned into single magnetic-domain structure within the pattern to it. Moreover, single magnetic-domain structure was acquired for the frequency of the pulse current used at the time of detached core formation on conditions 100Hz or less.
[0024] clear from the above result -- as -- NiFe, CoFe, and CoNiFe -- by choosing the pulse conditions at the time of detached core formation also about the cascade screen which consists

of which soft-magnetism layers using the alloy and detached cores, a different detached core from a soft-magnetism layer which contains oxygen in a layer was formed, consequently the reflux magnetic-domain structure of a magnetic-head core portion disappeared, and control became wide range and possible about magnetic-domain structure

[0025] Although the example which used the square wave pulse current in the above explanation at the time of formation of a detached core was explained, the wave of the pulse current controlled from the outside to formation of the detached core of this invention is not limited to this square wave, and the effect same to the above as a square wave pulse was confirmed also by methods, such as a triangular wave or a sine wave.

[0026]

[Effect of the Invention] Single magnetic-domain-ization of a magnetic-head core portion can be realized by between soft-magnetism layers separating magnetically the cascade screen which consisted of a soft-magnetism layer which formed membranes using the pulse-shape current to which negative bias was applied at the time of detached core formation as mentioned above, and a detached core, and making it join together magnetically in the direction of thickness, and reduction of a noise is attained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the example which made the current controlled from the outside at the time of soft-magnetism cascade-screen membrane formation of this invention the square wave pulse current
[Drawing 2] Drawing showing the example which made the current controlled from the outside at the time of soft-magnetism layer membrane formation of the soft-magnetism cascade screen of this invention the square wave pulse current
[Drawing 3] Drawing showing the example which made the current controlled from the outside at the time of detached core membrane formation of the soft-magnetism cascade screen of this invention the square wave pulse current
[Drawing 4] The cross section showing the composition of the soft-magnetism cascade screen of one example of this invention
[Drawing 5] Drawing showing change of film composition of the direction of thickness of the soft-magnetism cascade screen of this invention
[Drawing 6] (a) is drawing in which the magnetic-domain structure of a thin film magnetic-head core pattern shows the example of a single magnetic domain.
(b) is drawing in which the magnetic-domain structure of a thin film magnetic-head core pattern shows the example of two or more magnetic domains.
[Description of Notations]
1 Quantity of Electricity of the Direction of Plating Current
2 Quantity of Electricity of the Direction of Dissolution Current
3 Soft-Magnetism Stratification Process
4 Detached Core Morphosis
5 Substrate
6 Plating Ground Electrode
7 Soft-Magnetism Layer
8 Detached Core
9 Nickel
10 Iron
11 Oxygen
12 Soft-Magnetism Layer Field
13 Detached Core Field

[Translation done.]